HexSim: A flexible simulation model for forecasting wildlife responses to multiple interacting stressors

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Abstract

In a collaboration with the University of Washington, we have improved upon a popular life history simulator called PATCH, and in doing so produced a powerful new forecasting tool named HexSim. PATCH, our starting point, was spatially explicit and individual-based, and was useful for evaluating a range of terrestrial life histories, landscapes, and disturbance regimes. But PATCH had significant limitations. It was a single-population females-only model whose individuals were all identical. It had a modern but cumbersome interface, and it could not capture stressor or population interactions. These limitations compromised the model's realism and utility. In constructing HexSim from PATCH we have relaxed these and many other constraints; HexSim is a true multi-population and multi-stressor program. In addition, HexSim's populations are trait-based, which means individuals can have unique and dynamic properties. Having now finished HexSim, we will apply the model to evaluate wildlife responses to dynamic landscapes and disturbance regimes -- as part of EPA's ESRP.

Background

A The ecosystem service of interest is wildlife population viability and / or response to human activities.

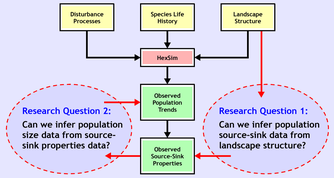
B The status of wildlife populations is valued because wildlife are a key component of healthy ecosystems.

C Possible clients and stakeholders for this endpoint include: concerned individuals, NGOs, and government entities.

D The goal is to develop a quick-to-compute plug-in for Envision.

E The challenge is that wildlife population dynamics are species-specific, and complex.

F Our approach is to capture the complex population dynamics in HexSim. Then a relatively simple proxy will be constructed for use in Envision.



Approach

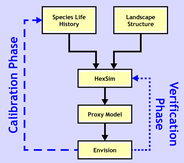
1 Simulate real-world complexity within the HexSim model, on a species-by-species basis.

2 Use HexSim simulation outputs to develop relationships between pattern (landscape structure) and process (species' dynamics).

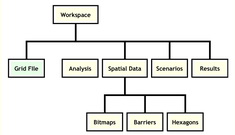
3 Capture the pattern-process relationship in a simple model that can function as an Envision plug-in.

Candidate Species Include:

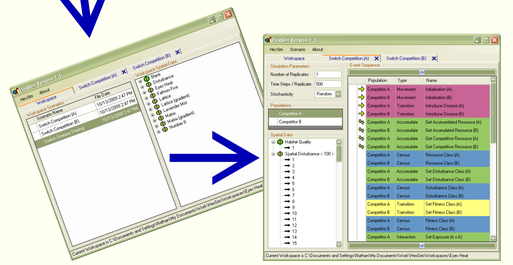
- Northern Spotted Owls
- Pileated Woodpeckers
- Great Horned Owl
- Northern Goshawk
- Western Medowlark
- Bobcat
- Red Fox
- and others ...



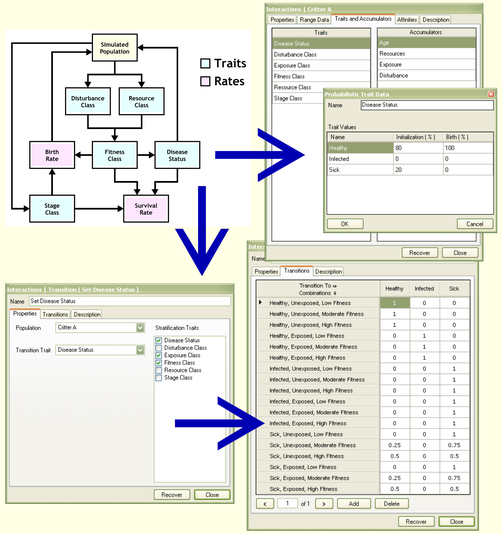
HexSim Basics



HexSim is a spatially-explicit, individual-based model that simulates terrestrial wildlife population dynamics and interactions. Simulations are based upon a user-defined life cycle. Individual behavior and experience are captured using a flexible trait scheme.

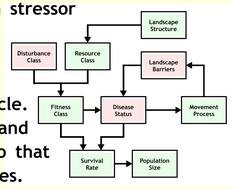


Traits (an example)

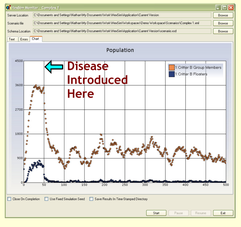


Interactions

HexSim can be used to simulate both stressor and population interactions. Stressor interactions can be simple or quite complex, and can be fully integrated into all aspects of the life cycle. Population interactions may be intra- and inter-specific, and can be designed so that they result in a wide variety of outcomes.



Dynamic Spatial Disturbance Off



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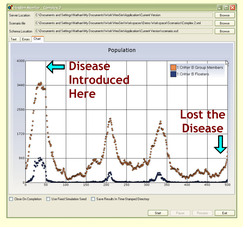
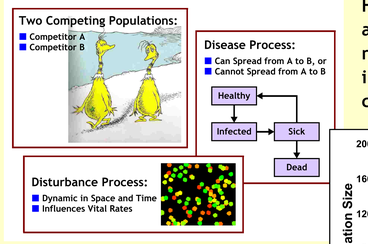
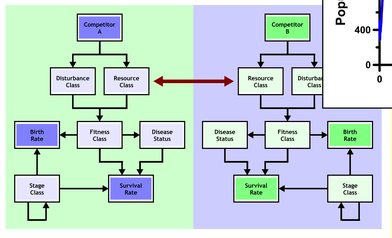
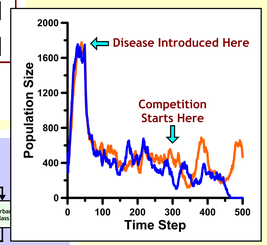


Populations



HexSim users may define as many populations as necessary. The timing of interaction events can be carefully controlled.





Usability and Reports

To improve its usability, we have developed a modern sophisticated GUI for HexSim. In addition, users can now easily generate a wide array of tabular and map-based output products and animated movies of simulation dynamics. HexSim 2.0 is bundeled with documentation and a set of worked examples designed to help users become familiar with its use and range of applications. Work on these products is ongoing.

Acknowledgements

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www.epa.gov/HexSim